Reply to the comments of Reviewer No. 1

Pradip Zamre on behalf of the authors
IAG, University of Stuttgart

February 22, 2022

Authors would like to thank the reviewer for the valuable comments and detailed review. Your comments and suggestions are very much appreciated and have been considered into the revised paper.

In the present document the comments given by the reviewer are addressed consecutively. The following formatting has been chosen:

- The reviewer comments are marked in blue and italic.
- The reply by the authors is in black color
- A marked-up manuscript is added containing the changes. Changed sections with regard to the comments by reviewers are marked in yellow. Changes related to major and additional comments are marked as R1:MaXX and R1:ACXX, respectively in the marked-up manuscript. Changes with regard to the common comments by both reviewers are highlighted in gray. Also, some changes are made for better understanding and have been highlighted in green.

Major comments "Ma"

1. "*A first conclusion is that turbines a significant reduction in the computation cost is realised through the initial simulation of the urban wind field without the wind turbines until a converged solution is obtained followed by the subsequent introduction of the wind turbines using this overlapping grid technique. Though this conclusion may be plausible, it is not demonstrated since there is no information presented about computational time, nor a comparison is made with the computation time for a more classical approach. This information needs to be added to the manuscript.*"

Thanks you for pointing it out. We have added following Table in the manuscript in Sect.2.6. Please see **R1:Ma1** (page 11, line 241).

Table 1: Overview of computational cost of different cases.

Simulation Cases	No. of cells (in Millions)	No. of cores	Time step [s]	Time required [Hrs]
Only urban terrain	127	8192	0.0278	69
Urban Terrain + 2 VAWTs (estimate)	153	8192	0.0031733	908
Urban Terrain + 2 VAWTs + current approach	127 (Set 1)/ 153 (Set 2)	8192	0.0278 (Set.1)/ 0.0031733 (Set 2)	330

Terrain only simulations allows a much larger time step and are just used to initialize the flow field (including propagations through the complete domain) for the subsequent turbine simulations that require a much smaller time step. For the "Only urban terrain" case, with 8192 core almost 3 days computation time is needed. If the wind turbines are simulated from the initial point, it would have taken approximately almost 38 days computation time. With larger time step in wind turbine simulations, other problems related to convergence and numerical stability arise. Overlapping grid technique and interpolation provides flexibility to introduce wind turbine later on in the fully developed turbulent flow field. With this approach for both the phases almost 14 days computation time is needed.

2. "*A second conclusion drawn is that the performance of wind turbine is significantly increased in rooftop positions. Especially the lower altitudes (10 and 12 m above the rooftop) are identified as having a "significant improvement of the performance". But I strongly doubt the validity of this conclusion. That is to say it is the result of the comparative calculations performed for the manuscript, but I am afraid it does not at all say something for a practical situation.*"

We agree that a general statement about the improvement in performance of wind turbine can not be made. The conclusion is valid only for the considered terrain and turbulent inflow data. The conclusion is based on the comparison between uniform inflow of 8 m/s and turbulent inflow for the same operating point. At heights 10 and 12 m over rooftop, the mean wind speed is less than 8 m/s, wind turbine provides C_P more than 0.38 (for uniform inflow C_P is 0.33) for the same TSR of 2.75 in turbulent inflow. We have added conditional statement to our findings, please see **R1:Ma2** (page 25, line 449).

3. "*The reason is the assumption about the operational condition of the rooftop wind turbines in the simulations. In line 330 the authors state: "... the rotational speeds are deduced depending on the wind speed and the operating point of $\lambda = 2.75$." This means that the rotational speed of the wind turbine is always instantaneously following the (highly) fluctuating incoming wind speed in the case of roof top application. And this is of course totally unrealistic. There is a lot of inertia in the system and the wind turbine control also has a role in the response of the rotational speed of the wind turbine on fluctuations in the incoming wind. The result is that the wind turbine will, most of the time, NOT run on its optimal tip speed ratio, and hence it results in power loss. And this is not modelled at all in the current simulations.*"

We apologize for not making this point clearer. The rotational speed and tip speed ratio are kept constant throughout all simulations. It is calculated beforehand based on the mean wind speed (from first set of simulations without wind turbine) and selected operating tip speed ratio of $\lambda = 2.75$. Also, we have added more discussion about the assumption of constant tip speed ratio, please see **R1:Ma3** (page 10, line 227).

We agree that for real operation in turbulent flow the TSR will vary but our intention was to study the occurring aerodynamic interactions. It has to be emphasized that the fluctuations in the wind speed occur over very short time period. Based on the time series of u component shown in fig. 12, it would have been practically very difficult to adjust the tip speed ratio for every second/revolution during simulations. Therefore, for simplification we assumed tip speed ratio and rotational speed constant for short time period of approx. 48 sec (which is considered in present study). The scope of present study is limited to the comparison of the aerodynamic performance of wind turbine in turbulent and uniform inflow.

Even though he turbulent inflow possesses higher energy content than uniform inflow, the energy is extracted at lower efficiency, as the consequence of optimal tip speed ratio is not maintained during operation in turbulent inflow. It is important to note that for fixed tip speed ratio and rotational speed, for higher wind speed (than mean wind speed), the output power increases and for lower wind speed (than mean wind speed), the output power decreases. Therefore, the moment and forces are averaged over 30 revolutions. This results in the maximum value of the power of the turbine at selected tip speed ratio and fixed rotational speed.

4. "*And evidently the same doubts hold for the third conclusion: "Therefore, it can be concluded that turbulence has a positive impact on performance, because again the assumption that here is an instantaneous adaptation of rotational speed to wind speed fluctuations is not realistic.*"

We agree with the comment of reviewer that an instantaneous adaptation of rotational speed to wind speed fluctuations is not realistic. In present study, there is no instantaneous adaptation of rotational speed and it is kept constant throughout in the simulations of VAWT in urban terrain.

Comments from supplement
Additional comments "AC"

1. "*wind turbine grids*"

We have reformulated the part of the sentence, see **R1:AC1** (page 1, line 8)

2. "*H-VAWT*"

We have added "H-VAWT" before wind turbine, see **R1:AC2** (page 1, line 15)

3. "*largely*"

We have added "mainly" before "related", see **R1:AC3** (page 1, line 17) instead of "is largely related to large-scale"

4. "*This is not clear enough. Most probably you mean that the number of available sites is reducing because of the expansion of offshore wind farms*"

We have reformulated the sentence, please see **R1:AC4** (page 1, line 19)

5. "*you need an external reference for this statement!!*"

We have added references, please see **R1:AC5** (page 1, line 21)

6. "*based on their axis of rotation*"

We have changed the order of the words, please see **R1:AC6** (page 2, line 38)

7. "*Hence*"

We have replaced "Furthermore" with "Hence", please see **R1:AC7** (page 2, line 39)

8. *"wind catching"*

We have added *wind catching* after omni-directional, please see **R1:AC8** (page 2, line 42)

9. *"A reference is needed here in which this is demonstrated/proven."*

We have added references, please see **R1:AC9** (page 2, line 46)

10. *"And"*

We have added "and" and modified the sentence, please see **R1:AC10** (page 3, line 68)

11. *"s"*

We have corrected the spelling, please see **R1:AC11** (page 4, line 96)

12. *"I would use a different word to explain the continuous improvement and extension of FLOWer"*

We have replaced "furthered" with "continuously developed", please see **R1:AC12** (page 5, line 102)

13. *"fixed pitch??"*

We have added "fixed pitch" before "two-bladed", please see **R1:AC13** (page 6, line 132)

14. *"The"*

We have removed "Also" and corrected the text , please see **R1:AC14** (page 7, line 145)

15. *"what do you mean with this??"*

We have modified the sentence, please see **R1:AC15** (page 7, line 153)

16. *"on top of building"*

We have replaced "over" with "on top of building", please see label of Fig. 4 **R1:AC16**

17. *"overall"*

We have changed the position of "overall" in the advances, please see **R1:AC17** (page 8, line 173)

18. *"on top of building"*

We have replaced "over" with "on top of building", please see **R1:AC18** (page 8, line 175)

19. *"Minor correction regarding spelling"*

The typo has been corrected, please see **R1:AC19** (page 8, line 179)

20. *"Turbulence is"*

We have added "Turbulence is" and removed "it was", please see **R1:AC20** (page 9, line 186)

21. *"are"*

We have replaced "were" with "are", please see **R1:AC21** (page 9, line 189)

22. *"But seems to be in contrast to the remark made in the introduction. There (line 125) you state: The examined wind turbine .... VAWT designed by Li et al. (2016) with the airfoil section NACA0021. Also, it has been investigated experimentally in the wind tunnel as well as in the field.*

I do understand that here you talk about about an upscaled version (factor 3.5) of the tested H-rotor VAWT so in strict sense there is no experimental/field data available, but it will be quite helpful to also introduce some comparison between your numerical results and the experimental results from Lie et al. This doe not need to be treated her but can be done later on in the manuscript.
Hence I would like you to more explicitly state here that there are such data for the original H-rotor VAWT."

We have added text about experimental data, please see **R1:AC22** (page 9, line 195). The experimental data for unscaled wind turbine is added in the fig. 8.

23. "*P (capital P) for Power lower case p for pressure!!*"

We have corrected the typo, please see **R1:AC23** (page 9, line 202)

24. "*If you use one of .. you should write bases (plural). Maybe better to simply state "a basis" instead.*"

We have corrected the typo, please see **R1:AC24** (page 9, line 202)

25. "*This is not clear enough, so you need to improve this explanation. Based upon the current text I see two different approaches: 1) are the wind turbine simulations done in the same numerical environment (model) as the urban landscape? In other words: do you first simulate the urban landscape without the presence of the wind turbine, and then add the wind turbine in the urban landscape? OR 2) do you take the average of the flow variables and use them as an input for a separate simulation of the flow about the H-rotor VAWT?*"

We have modified the part of paragraph , please see **R1:AC25** (page 9, line 204)

26. "*This is non sense: the heights ..... should be the bottom of the rotor swept area. Replace the sentence with something that makes sense.*"

We have modified the sentences , please see **R1:AC26** (page 9, line 211)

27. "*I would say the shape of the building, the wind direction and the local height of the flow separation area on top of the building are the determining factors for the required minimum height. Chord length can never be a key determinating factor for determination of the minimum height. So you should:*
1) provide a critical assessment of Siddiqui et al to fond out whether it is indeed the chord length that determines the optimal performance (I could possibly imagine it is another parameter related to the chord length).
2) refer to (one or tho of the many) publications in which the relation between the minimum required height and the height of the separated boundary layer identified as THE determining factor for the height of the rotor."

(a) We agree that shape of the building, the wind direction and the local height of the flow separation area on top of the building are the determining factors for the required minimum height. The chord was just used for normalization of the ground clearance. However, to avoid ambiguity, the text has been removed.
(b) The ambiguous text has been removed and statement about factors affecting the height selection is added. Please see **R1:AC27** (page 9, line 212).

28. "*away from what?? Be more clear, you probably mean away from the rooftop.*"

We have modified the sentence **R1:AC28** (page 10, line 215).

29. "*see earlier remark (line 192) about clarifying the sequence of computation.*"

We have modified the sentence **R1:AC29** (page 10, line 218).

30. "*time*"

We have replaced "costs" with "time" **R1:AC30** (page 10, line 221).

31. "*in the case with*"

We have added "in the case of", please see **R1:AC31** (page 10, line 223).

32. "*Active*"

We have corrected the text, please **R1:AC32** (page 10, line 226).

33. "*are*"

We have rectified the Typo, please see **R1:AC33** (page 11, line 236).

34. "*What are these reference conditions? Please add a table with both the geometry and optimal operational conditions (such as optimal lambda/TSR).*"

Reference conditions and geometrical parameters are now listed in Table 1. The optimal $C_P - \lambda$ is approximated from $C_p - \boldsymbol{\lambda}$ curve in Fig. 8. The experimental data for original wind turbine is also added in the Fig.8. We agree and have rectified the sentence, please **R1:AC34** (page 11, line 254).

35. "*capital P*"

We have modified the notation as C_P, please **R1:AC35** (page 12, line 257).

36. "*please provide the complete sequence of TSR's e.g.: 1.2; 1.8; 2.0; .755; 3.0 and 4.0.*"

We have added complete sequence of TSR in the sentence, please see **R1:AC36** (page 12, line 275).

37. "*?????? The variation of moments and forces over one revolution (azimuthal position) is complex independent of TSR, so why emphasise additional complexity with increasing TSR. My suggestion is to simply delete this sentence because it adds nothing in terms of understanding.*"

We agree and have deleted the sentence, please see **R1:AC37** (page 13, line 280).

38. "*I think that you mean is that these variations are intrinsically present in operational VAWT's and that is much stronger than "involved". So modify sentence accordingly!!*"

We have modified the sentence, please see **R1:AC38** (page 13, line 283).

39. "*A more or less*"

We have added "A more or less" in the sentence, please see **R1:AC39** (page 13, line 283).

40. "*at azimuth angles xxx to yyy,* "

We have modified the sentence and added "at azimuth angles" in sentences, please see **R1:AC40** (page 13, line 285).

41. "*But this also holds for TSR=1.2. There is a difference in local shape for the lowest TSR and the location of the max. moment but the increase, a max around 90 degrees and then a decrease to zero is seen for all TSR's*"

Authors have modified the sentences, please see **R1:AC41** (page 13, line 286).

42. "*This is very strange since the moment is the product of tangential force and radius. I would say why burden the reader with this, simply change the sign in in figure 7b and erase this sentence.*"

We have deleted the sentence and have changed the sign of tangential and normal forces in Fig. 7, please see **R1:AC42** (page 14, line 311). Similarly, we have changed plot in Fig. 15 and Fig. 16.

43. "*evidently an excellent (since moment is the product of tangential force and radius).*"

We have added "evidently an excellent" in the sentence, please see **R1:AC43** (page 13, line 290).

44. "*I simply do not understand this. With increasing azimuth the tangential force reduces in the second quadrant isn't it?*"

We have removed the ambiguous the sentence, please see **R1:AC44** (page 13, line 290).

45. "*??? I would say "present"*"

We have rectified the sentence, please see **R1:AC45** (page 13, line 292).

46. "*airfoil*"

We have corrected the sentence, please see **R1:AC46** (page 13, line 295).

47. "*complicated*"

We have added word "irregular" instead of "complicated", please see **R1:AC47** (page 14, line 299).

48. "*???? leads to stalled conditions where?? The stalled aifoil is located upstream an now we are talking about the downwind part of the rotor!* "

We apologize for the negligence. We have corrected the sentence. please see **R1:AC48** (page 14, line 300).

49. "*Do you also have a clarification why the wake effect of the shaft is much less visible for the larger TSR's??* "

At higher λ, the flat nature of moment curves from azimuth 180° to 360° and decreased effect of the shaft may be loosely connected to each other. At higher λ, the rotating blades at high speed, block most of the wind flowing through the wind turbine and the flow field near shaft is trapped.

We have added sentences, please see **R1:AC49** (page 14, line 305).

50. "*Maybe you can draw a smoothened curve as well to get a better guestimate about the max CP but keep the dashed line and the 6 numerical values as markers.*
And you may also think about adding the wind tunnel CP-lambda curve from the experiments of Li et al. (2016). of course with the remark that this is a scaled version of the numerical rotor."

We have added CP-lambda curve from the experiments of Li et al. (2016) and have drawn smooth curve for scaled up wind turbine, please see Fig. 8 **R1:AC50**. We have also added explanation for difference in the curves.

51. "*You tell this more or less as a surprise, where it is evident. Even when the moment curves would have been identical the CP is larger because the omega (rotational speed) is larger for TSR=2.0 So reformulate this sentence!*"

We have modified sentences, please see **R1:AC51** (page 15, line 321).

52. "*I would expect a different, better explanation here. Not only mention the difference in operating point but also the physical explanation. For TSR larger than the optimal value the thrust goes further up (compared to the optimal thrust) while the power goes down. And this is exactly what is seen here.*"

We have modified sentences, please see **R1:AC52** (page 15, line 325).

53. "*The.*"

We have modified sentences, please see **R1:AC53** (page 16, line 338).

54. "*What are these dashed circles? Why have they been added to the plot? They do not offer any additional information and are only confusing!!*"

The dashed circles were added to show the accelerated flow. However, considering the scale it becomes confusing. We agree to the comment from reviewer and have modified the figures, please see **R1:AC54**.

55. "*please add in the figure itself that the figures of H in the graph refer to the standard deviation (and e.g. NOT to the shape of the rotor).*"

We have added details "H in the graph refer to the standard deviation and NOT to the shape of the rotor" in the Fig. 11, please see **R1:AC55**.

56. "*Add a table in which you provide the numerical values of wind speed, wind direction (skewness) as well as their standard deviations for the 6 locations. You may also expand the current table 2 to provide this information!*"

We have extended Table 2 and have added information about skew angles, mean wind speed as well as standard deviations in the Table 3, please see **R1:AC56**.

57. "*These are, literary, very empty plots that tell little about the conditions for which you simulate both rotors. Discard this figures and make table 2 as suggested above (in remark at line 296) much more complete!!*"

We agree and have removed the figures and added the details in the Table 3, please see **R1:AC57**.

58. "*Add a figure 14 with the same information about the vertical component of the wind speed!!*"

We have added the figure 13 showing vertical component, please see **R1:AC58**.

59. "*expand this table with values for standard deviation of average wind speed (though that is very similar to TI and also all values for vertical wind speed component.*"

We have added the details in the Table 3, please see **R1:AC59**.

60. "*?? what is a "long averaged" wind speed?? Explain this or discard "long"*"

With long average wind speed, we meant averaged value over longer period of 300 sec compared to the physical time considered for wind turbine simulations. We agree that it is confusing and have corrected the sentence, please see **R1:AC60** (page 22, line 368).

61. "*This gives rise to many questions:*
1) How does the reader know that TSR=2.75 is about the optimum (you have not yet introduced this).
2) but much more important: so from what I understand the TSR is kept constant in this (very) turbulent environment.
This is a physically unacceptable assumption. In a turbulent environment the TSR will vary significantly. This has to do with the inertia of the rotor, inertias from both the mass of the rotor, but also the aerodynamic inertia of the rotor system ("dynamic inflow effects"). And then there is (in practice) also the inertia of the complete rotating system as well as the control of the turbine that will make constant TSR operation impossible. "

(a) We agree and have added information, please see **R1:AC61a** (page 22, line 374).

(b) We agree that for real operation in turbulent flow the TSR will vary but our intention was to study the occurring aerodynamic interactions. It has to be emphasized that the fluctuations in the wind speed occur over very short time period. Based on the time series of u component shown in fig. 12, it would have been practically very difficult to adjust the tip speed ratio for every second/revolution during simulations. Therefore, for simplification we assumed tip speed ratio and rotational speed constant for short time period of approx. 48 sec (which is considered in present study). The scope of present study is limited to the comparison of the aerodynamic performance of wind turbine in turbulent and uniform inflow. We have added discussion about assumptions of constant tip speed ratio and literature (in which the tip speed ratio is kept constant under turbulent inflow), please see **R1:AC61b** (page 10, line 227).

62. "*So now it becomes even more confusing. -do you average TSR and rotational speed? -do you simulate with these averaged values or do you average the results in constant TSR operation??.* "

We apologize for the ambiguity.

(a) TSR and rotating speed are kept constant. Variables such as moment, tangential and normal forces are averaged for 30 revolutions.

(b) Based on mean wind speeds at selected rooftop height and selected TSR 2.75, the rotational speeds are calculated. The explanation has been added, please see **R1:AC62** (page 22, line 379).

63. "*use dashed lines for the indication of the standard deviations.Now the curves are less visible due to the overlap with the indication of the standard deviations.*"

We have reduced the thickness of standard deviation bars and have update the Fig. 15, 16, 18 and 19. Please see **R1:AC63**

64. "*This cannot be clearly seen, Change the line thickness and/or line shape in the figure for the standard deviation markers!*"

We have reduced the thickness of standard deviation bars and have update the Fig. 15, 16, 18 and 19. Please see **R1:AC64** (page 23, line 386)

65. "*change this in better wording!* "

We have corrected the sentence, please see **R1:AC65** (page 23, line 388).

66. *"It would help if you could add a figure (or 2) in which you present the two graphs simultaneously for easier comparison."*

We have added a fig. 17 comparing moment of single blade in uniform inflow and in urban terrain under turbulent inflow (averaged), please see **R1:AC66**.

67. *"discard figures 16b and 17b and give the CP values in a small table!!"*

We have discarded figures 16b and 17b and added the Cp values in Table 4. Please see **R1:AC67**.

68. *"Where can this be seen??"*

We have corrected the sentence, please see **R1:AC68** (page 23, line 390).

69. *"So it will be nice to also present these values here: calculate the projected frontal area's for the six wind turbine positions (you know the (average) skew angles) and see how much they contribute to the increase in CP."*

In non-skewed case, the frontal area $D \times h$ is 29.4 and Cp is inversely proportional to area assuming all the remaining variables are constant. We calculated the decrease in frontal area caused by skewness as $D \times (h - h \times (R \times tan\beta))$.

Table 2: Scaling-up of VAWT

Skew Angle	Frontal Area	1/A	$C_P/C_{P-nonskew}$
0	29.4	0.034	1
12.32	24.049	0.04158	1.2229
10.93	24.6687	0.04053	1.192
6.74	26.50	0.03773	1.1097
6.68	26.53	0.03769	1.1085
6.41	26.6475	0.03752	1.1035
5.26	27.144	0.03684	1.083

By this method, the estimated increase in Cp is approx. 22% at 10 m height above A. We got 21% increase at the same position by CFD. The effect of skewness and turbulence do overlap. Only one effect cannot be separated precisely. Therefore, we have presented only the total influence.

70. *"I would state this differently expressing that the turbulent inflow causes the inflow conditions in the downstream part of the rotor to be more random, and hence "less phase locked" (fixed to a certain azimuthal position). "*

We have reformulated the text, please see **R1:AC70** (page 24, line 402).

71. *"Is this true?? The main determining factor for the local flow direction is still the azimuthal position!!"*

We have removed ambiguous text.

72. *"You cannot see this unless you also provide the same figures for the uniform flow case!! So add such a figure!!"*

We have modified the sentences, please see **R1:AC72** (page 24, line 409). The large deviations in moment indicates influence of complex inflow. Instead of comparing instantaneous moment, we have compared averaged moments in fig. 17. Therefore we do not prefer to add the picture to avoid manuscript being longer.

73. "*of what?*"

We have corrected the sentence, please see **R1:AC73** (page 24, line 413).

74. "*Discard/change this sentence following the advice to put the values in a table,*"

We have removed the sentence, please see **R1:AC74** (page 24, line 416).

75. "*This was known/realised way before Mollestrom presented his article, so you better find a better, earlier published reference.*"

We have added an old reference, please see **R1:AC75** (page 24, line 420).

76. "*Though this is a very nice artistic picture, it adds little to non to the understanding of the complex wake flow. Replace it with a (maybe more boring) better picture that provides insight!*"

We agree and have removed the figure, please see **R1:AC76**.

77. "*bladed*"

We have corrected the sentence, please see **R1:AC77** (page 25, line 429).

78. "*You have not demonstrated this reduction in cost in the manuscript. In the beginning of the paper you suggest that it will help to reduce computational cost (time). But this is not substantiated with any numbers at all regarding the used computational time. So please add sufficient information to be able to draw this conclusion.*"

We have added more information, please see **R1:Ma1** (page 11, line 241) and **R1:AC78** (page 11, line 241).

79. "*Without a proper answer/discussion about your assumption of constant TSR operation in the strongly turbulent distorted wind field on top of a roof, this conclusion cannot be drawn.*

I can seen that this is the result of your simulations, but if these simulations are far away from realistic operation of a wind turbine in such an environment this in an unrealistic result. Recent research has shown that the inertia and the control system of a small wind turbine in complex wind conditions can completely destroy power production!! "

We agree that the assumption of constant TSR needs discussion. The same has been discussed in the reply to the comment 61 in this document and have been added in the revised manuscript, please see **R1:AC61b** (page 10, line 227).

80. "*This is not what is meant by data availability. What is intended here is a link/reference to the data you produced during your research. This may be a University Stuttgart database that is approachable and retrievable, or similar.*"

We agree to your point and have removed the text.

Reply to the comments of Reviewer No. 2

Pradip Zamre on behalf of the authors
IAG, University of Stuttgart

February 22, 2022

The authors would like to thank the reviewer for the efforts and valuable comments. Your comments and suggestions are very much appreciated and have been considered into the revised paper.

In the present document the comments given by the reviewer are addressed consecutively. The following formatting has been chosen:

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Major comments "Ma"

1. "*On page 2 line 41 is stated that the wake recovery is faster for a VAWT than a HAWT. Is this a postulate or can you give a reference clearly showing this ?*"

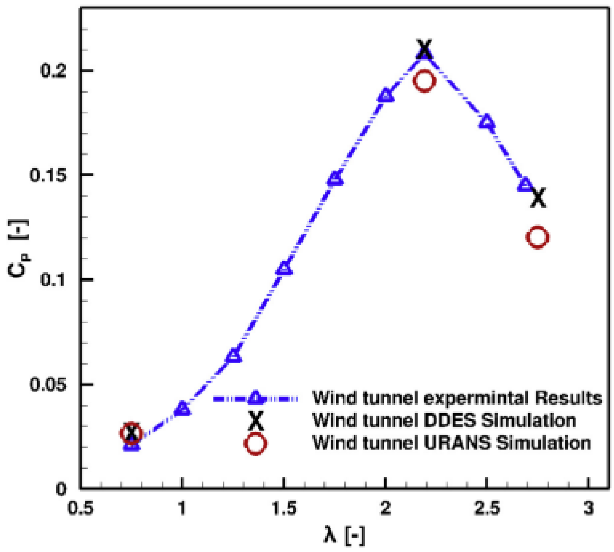
Thank you for pointing it out. The following reference is added in the manuscript regarding the statement about wake recovery, please see **R2:Ma1** (page 2, line 43)

Kinzel, M., Mulligan, Q., & Dabiri, J. O. (2012). Energy exchange in an array of vertical-axis wind turbines. Journal of Turbulence, 13, N38. doi:10.1080/14685248.2012.712698

2. "*The chosen VAWT has a very low aspect ratio of L/D=0.6, that must give a highly 3-D flow due to large end effects and makes the calculations more challenging and perhaps more uncertain. This is not mentioned and some flow visualizations of the flow past the rotor would be nice. The turbine also have an unconventional Cp-lambda curve for a VAWT, Fig. 8. The peak Cp occurs at a very low tip speed ratio and can you explain why.*"

(a) We agree that low aspect ratio makes calculations challenging. The original unscaled wind turbine with aspect ratio L/D=0.6 has been studied with DDES approach using FLOWer in the following reference and the results has been validated with the experimental data.

Dessoky, A., Lutz, T., Bangga, G., and Krämer, E., Computational studies on Darrieus VAWT noise mechanisms employing a high order DDES model, Renewable Energy, Volume 143, Pages 404-425, https://doi.org/10.1016/j.renene.2019.04.133 , 2019



The plot from above mentioned reference shows validation of power coefficient at three distinct operating points for the unscaled wind turbine. Also, we have added information in text, please see **R2:Ma2a** (page 6, line 143)

(b) Now, we have added Z vorticity contours of wake for different tip speed ratios in fig 9 and related explanation, please see **R2:Ma2b** (page 15, line 308)

(c) The $C_P - \lambda$ curve is influenced by parameters such as airfoil, solidity, free stream velocity. In general, peak Cp occurs at low tip speed ratio in case of VAWT. The chosen turbine has relatively moderate solidity. With increasing solidity, the peak C_P of VAWT moves to lower λ.

3. "*On page 9 is refered to a 2-D DES simulation. I assume this is 2.5D ?.*"

On page 9, the reference of 2D simulations is related to simulations from literature, which were actually conducted as 2D simulations.

4. "*On page 11 is stated that the tip speed ratio is kept constant by varying the rotational speed. This must cause a large variation in airfoil Re number. Could this be important for the solution ? Perhaps you could state the Re range.*"

We agree that the Reynolds number will vary according to the the tip speed ratio. Tip speed ratio λ is dependent on radius (R), rotational speed ω and free stream velocity U_∞. In the cases mentioned on page 11, the λ is changed only by variation in ω, while U_∞ and radius (R) are kept constant at 8 m/s and 3.5 m, respectively. The resulting Reynolds number based on chord are given in the following table

Table 1: Re_c at different TSR

λ	ω [rad/s]	V_t [m/s]	Re_c [-]
1.2	2.743	9.6005	6.096 E5
1.8	4.114	14.399	9.143 E5
2.0	4.571	15.9985	10.158 E5
2.75	6.286	22.001	13.970 E5
3.0	6.857	23.9995	15.239 E5
4.0	9.143	32.0005	20.319 E5

where ω is rotational speed, V_t is tangential velocity at airfoil and Re_c is Reynolds number based on chord. We have added the Reynolds number range in revised manuscript, please see **R2:Ma4** (page 12, line 265)

5. "*You may state it somewhere, but please specify more clearly the flow direction used in Figure 9. The resulting flow on the roof tops must be very dependent on wind direction.*"

Thank you for pointing it out. In the revised manuscript, we have added the flow direction in fig 10, please see **R2:Ma5**.