The authors would like to thank the reviewer for his efforts and valuable comments. They are very much appreciated and will be/are incorporated into the revised paper!

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

- The reviewer comments are marked in blue and italic.
- The reply by the authors is in black colour.
- Changed/extracted text sections are in green boxes.

A preliminary revised manuscript which incorporates the comments of both reviewers has been prepared. The made changes with respect to the 1st reviewer are listed below. In this respect the authors would like to mention that the revised manuscript is now significantly larger than the indicative 30 to 40% requested in the Torque invitation.

General comment:

"The paper investigates three dimensional and unsteady effects of a moving trailing edge flap on the aerodynamic loads of DTU 10 MW reference turbine through CFD analysis. Emphasis is given on less understood till now three dimensional effects which are definitely not captured by existing state-of-the-art BEM based aeroelastic tools used in the assessment of load alleviation capabilities of flaps. The work is very interesting and relevant to the research work recently undergone in EU funded projects INNWIND.EU and AVATAR."

Thank you very much!

Specific comments:

-In section 2, consider moving equation 2 up below equation 1, and add "According to Theodorsen's method the lift is given by:" and explain the terms of the equation afterwards.

Thank you. This has been changed.

-In section 2, I believe it is not mentioned in the text what is the amplitude of the periodic flap motion used in deriving the results of figure 2. An idea could be to plot transfer function results of DCL/Dbeta in figure 2 instead of DCL.

Thank you. That's true and was missed. The transfer function $dc_l/d\beta$ is plotted now and the text was slightly changed to account for this.

… The instantaneous lift coefficient $c_l(t)$ can be analyzed with regard to the amplitude Δc_l and phase shift Φ of the lift response in relation to the input flap signal. Δc_l can also be evaluated normalized with the amplitude of flap deflection ($\Delta c_l/\Delta\beta$). …

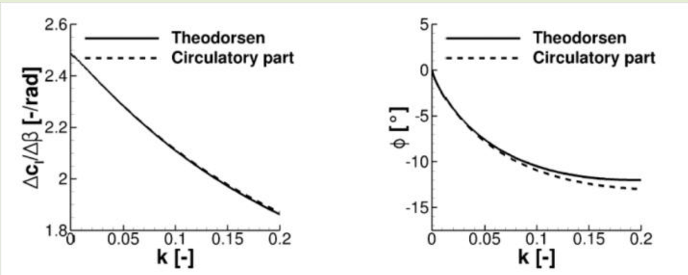

Figure 3. **Normalized lift amplitude $\Delta c_l/\Delta\beta$ and phase shift according to Theodorsen**

-In section 3.5, second paragraph. It would be instructive for the reader if you describe in detail inflow/operational conditions that lead to the dimensionless parameters used in the 2D analysis. For example inflow velocity, rotational speed (or tip speed ratio), spanwise position of the section.

Thank you. A table showing the rated operational conditions has been added and is referenced throughout the text. (2^{nd} paragraph, Sect. 3.5)

… The simulations have been performed at a realistic inflow extracted from the 3D rotor case at rated operational conditions. These conditions are specified in Table 2.

Table 2**. DTU 10 MW turbine, rated operational conditions**

Wind speed	Rotational speed	Blade pitch	Tip speed ratio
11.4 m/s	9.6 rpm	0°	7.86

At 75% radius, the Reynolds number was determined to 15.4 millions, Mach number to 0.2 and the AoA to 6.5°. …

- In section 4.1, page 10, below line 10, it is the effect of the induced drag that the authors are describing. When the flap angle increases, lift increases so the intensity of the trailed vorticity increases, and therefore downwash and induced drag increases while effective AoA decreases. The opposite happens at negative flap angles. A similar discussion is made on section 4.3. It is again the effect of the induced drag that differentiates the Cdmean over Cd. The comment here is that it seems that discussions in sections 4.1,4.2 and 4.3 are somehow separated although they should be finally linked together. Especially the results of figure 16 and 17 must be linked to the results of figure 10,11 and 12. Also the concept of the induced drag (which is a consequence of course of the downwash effect) could be introduced.

Thank you very much for this valuable comment!

The paragraph in section 4.1 starting from line 9, page 10, was revised as follows. Please note that the torsion moment has been added as suggested by the second reviewer.

In Fig. 12 and Fig. 13 sectional distributions of driving force, thrust and torsion moment over the blade radius are shown for 1p and 6p case respectively. Four instantaneous solutions are plotted for maximum, minimum and 0° flap deflection. Thrust shows the expected increase and decrease in the flap section with a smooth load distribution over the flap edges. This smoothing is a consequence of the positive effect of the flap deflection on neighboring blade sections as described in Sect. 2.2. While trailing vorticity reduces the effect of the flap in the flap section compared to 2D, the sections next to the flap part produce higher/lower lift due to the induced upwash/downwash for respectively positive/negative flap angles. The change of sign in induced velocity caused by the flap edge vortices is also apparent in the driving force as significant steps are appearing at the transition between flap and rigid rotor part. An opposite behavior of sectional driving force in relation to thrust can be noticed by comparing the diagrams. When thrust increases locally in the flap area, the driving force decreases in relation to neighboring sections. This results again from the strong influence of drag on the driving component at rated wind turbine conditions and will be explained on the basis of 1p case as follows. Due to the low reduced frequency in this case (k = 0.024), the influence of shed vorticity is still weak. For maximum positive deflection (t/T_{Flap} = 0.25) the increase of trailing vorticity causes a downwash in the flap section. This reduces the effective AoA and leads to a rise of induced drag in addition to the drag augmentation caused by the flap deflection itself. The overall drag increase is compensated by the lift increase resulting from the flap deflection and relative to 0° flap deflection an increase of driving force is achieved. The neighboring sections to the flap experience an additional upwash in case of positive

deflections. Consequently, the induced drag reduces associated with the lift increase and these sections produce in total a higher sectional driving force. Similar observations are made vice versa for maximum negative deflections, but the driving force increase in the flap section is less pronounced compared to the decrease in case of positive deflection. Further elaborations in this respect can be found in Sect. 4.3, in which lift and drag forces are extracted and compared. With regard to the torsion moment around the pitch axis a strong oscillation is seen in flap section with steep gradients at the flap edges. This torsion moment or c_m oscillation is typical for trailing edge flaps (Ferreira et al., 2015) and its effect on the overall performance of the flap concept needs to be investigated separately in an aero-elastic simulation when the blade is able to twist.

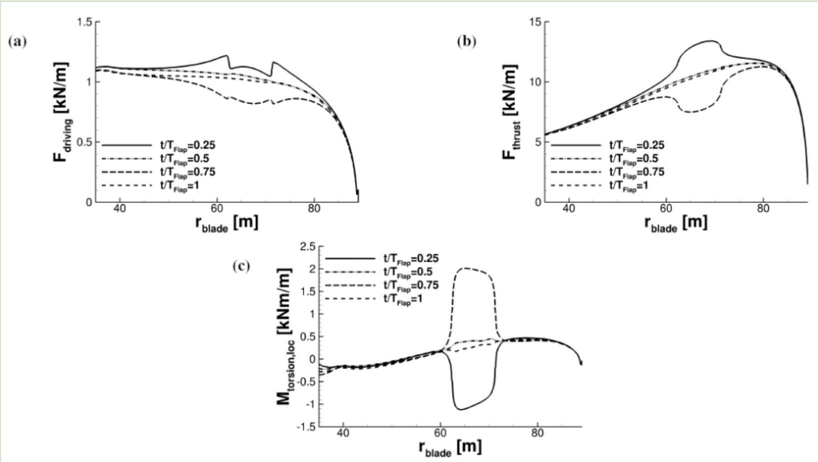

Figure 12. **1p sectional forces (driving force (a), thrust (b) and local torsion moment (c))**

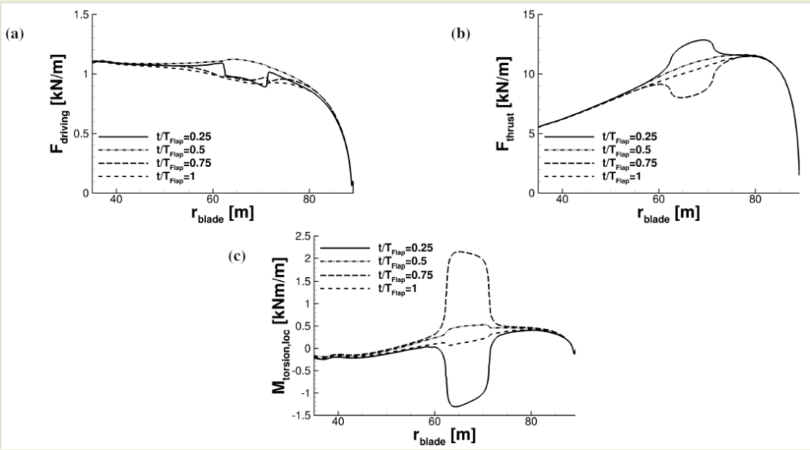

Figure 13. **6p sectional forces (driving force (a), thrust (b) and local torsion moment (c))**

The concept of induced drag is introduced in section 2 (page 2, line 16):

Generally the efficiency of the flap with regard to local lift increase or decrease is reduced by trailed vorticity in the 3D case. The flap deflection causes an additional downwash or upwash in the flap section. This leads to a respectively lower or higher effective AoA in the 3D case and consequently to induced drag in relation to the baseline AoA. It is worth noting that with respect to the case without flap deflection (β=0°), the induced drag is increased in case of positive deflections and decreased in case of negative deflections.
The adverse effect of trailing vortices in the flap section is however countered by a positive effect in the blade parts adjacent to the flap section. Caused by the sign change of induced velocities over the flap edge, the described effects for the flap section are experienced vice versa at these blade parts. With regard to integral loads such as power and thrust, this effect opposes the negative impact of trailing vortices in the flap section.

Please note that in the revised manuscript, Sect. 2 is divided in three subsections in connection to the comments by the second reviewer. (1. 2D airfoil, 2. 3D rotor blade, 3. Theodorsen theory)

In section 4.3 bigger modifications have been performed in order to describe the intention of the section more clearly. This is also linked to the next comment by the reviewer:

-Also in section 4.3. Why do we need AoA for in a CFD simulation? The only reason why we would like to have a consistent definition of the AoA is in order to be able to compare against BEM or lifting line models and tune them. Perhaps this objective should be pointed out in the text because otherwise the need for paying so much attention on extracting AoA is not clear.

Changed introduction to section 4.3 (page 14, line 8):

4.3 **Influence of varying AoA in 3D**

As observed in the previous section, in the 3D rotor case the local AoA is oscillating over a flap period as a result of dynamic inflow. This means from an aerodynamic point of view that two unsteady mechanisms are superimposed: pitch and flap oscillation. The objective of the present work is though to characterize and quantify unsteady 3D effects solely due to flap deflection and consequently some preliminary considerations have to be made. For this purpose the 1p frequency is regarded in the following, for which quasi-steady assumptions are eligible and the reduced axial velocity method can be applied. The variation of the local inflow velocity and the AoA is shown in Fig. 17 for the mid flap position. While the inflow velocity shows no major variations, the AoA oscillates with an amplitude of 0.6°.

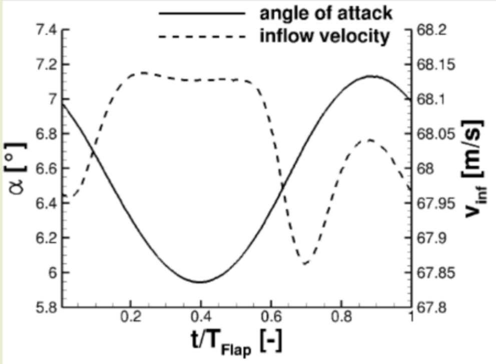

Figure 17. **1p instantaneous inflow conditions 3D, 75 % radius**

When the instantaneous AoA is extracted from the 3D simulation it includes the oscillations caused by both mechanisms, dynamic inflow and flap oscillation. The dynamic inflow oscillation represents an oscillation of the baseline AoA as a result from the variation of the axial induction of the turbine. In contrast the oscillations caused by the flap originate from the downwash of 3D trailing vorticity which changes the effective AoA. As the objective is to quantify 3D trailing vorticity, the flap-caused AoA oscillation should be mimicked to the aerodynamic coefficients, while in theory the influence of the dynamic inflow caused oscillation should be eliminated. A clear distinction between both oscillations is however not possible and requires further aerodynamic modelling. Nevertheless, the influence of the overall AoA oscillation on the 3D extracted aerodynamic coefficients can be assessed.

Link to section 4.1 and the sectional distribution of driving force and thrust and changed summary of section 4.3 (page 15, line 4):

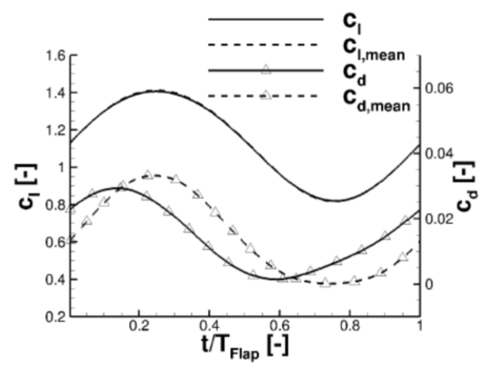

Figure 18. **1p comparison of lift and drag, 3D instantaneous/ 3D mean, 75 % radius**

… Consequently the results for c_l and $c_{l,mean}$ are very similar. c_d and $c_{d,mean}$ differ strongly. Based on the previous considerations this difference consists of two parts, induced drag which originates from trailed vorticity and the drag resulting from the AoA oscillation caused by dynamic inflow.
The plot in Fig. 18 can be directly linked to the curves for driving force and thrust in the 1p case displayed Fig. 11 (in original manuscript: Fig. 10) and Fig. 12 (in original manuscript: Fig. 11). Thrust is dominated by c_l and consequently the progressions over a flap period are very similar. The driving component is a superposition of both forces which are oscillating at a different phase. This can be noticed for example at the time instance when the flap is deployed to maximum deflection (t/T_{Flap} = 0.25). c_l but also $c_{d,mean}$ is maximal and as a result the progression of driving force flattens. Vice versa the phenomenon is observed at minimum deflection (t/T_{Flap} = 0.75).
With regard to the objective of this section, determining the influence of the AoA oscillation on the 3D extracted aerodynamic coefficients, it can be concluded that the extracted c_l is only minor affected and it is eligible to use $c_{l,mean}$ for the comparison to 2D simulations and the evaluation of the impact of trailing vortices. With respect to c_d it is difficult to clearly distinguish between the part caused by the AoA oscillation and the induced drag from trailed vorticity. In order to judge the impact of trailing vortices on c_d, this differentiation is however necessary and the part caused by the AoA oscillation needs to be eliminated. The emphasis of the comparison to 2D simulations is hence on lift and moment coefficient.

-The term downwind/upwind is used for the effect of induced velocities. Perhaps it would be better to use upwash/downwash.

Thank you. The authors agree and this has been changed through out the text.

In addition to the above changes, two smaller corrections had to be performed by authors for correctness:

- Table 2, original manuscript: An error was found in post-processing for β=0° (evaluation of wrong revolution) which changed the results to a power of 10.71MW (reduction by 0.37%) and to a thrust of 1790kN (reduction by 0.17%). The conclusions are unaffected.
- Table 3, original manuscript: corrected typo for (∆cl,3D /∆cl,2D) to 73%

Technical comments. Some editorial typo/syntax changes,

-Page 2, line 17, “However the blade parts next to the flap. . ..”, could be better to replace “next” by “adjacent”?

- Page 2, line 23,”. . .which in turn influences (in the) blade loads”

-Page 3, line 25, “Both is (are). . .”

Thank you. All of the above comments have been changed as specified.

-Page 7, line 13, ". . .corresponding to the sixth (six times or sixth harmonic) of the rotational velocity"

Thank you. This has been changed to:

…corresponding to six times the rotational frequency…

-Page 9, line 12, ". . .not updated (in) every time step. . ."

-Page 9, line 16, ". . .correspond to reduced (of) frequencies. . ."

-Page 9, line 18, "A higher (frequent) frequency . . ."

Thank you. All of the above comments have been changed as specified.

Page 10, below line 5, It is not clear what does the sentence in the parenthesis mean (respectively 0.2 in Fig.10a). Also the next sentence could be re-phrased. In simpler words it is the superposition of two variations with the same frequency by different phases that causes the effect.

Thank you. The sentences are re-phrased as follows.

… For the 3p and 6p case, a second superimposed oscillation is visible from t/T_{Flap}=0.8-1.2 (in Fig. 11a respectively 0.2 on the x-axis). This oscillation results from the overlay of lift and drag forces in the rotor plane. At higher frequencies drag shows a significant amplitude increase as seen in Fig. 6 and additionally c_l and c_d are oscillating with different phases. The superposition of both force components leads to the curve progression seen in the 3p and 6p case. This phenomenon in driving force is especially present at operational conditions with a pitch angle of 0°, for which the impact of drag is high. …

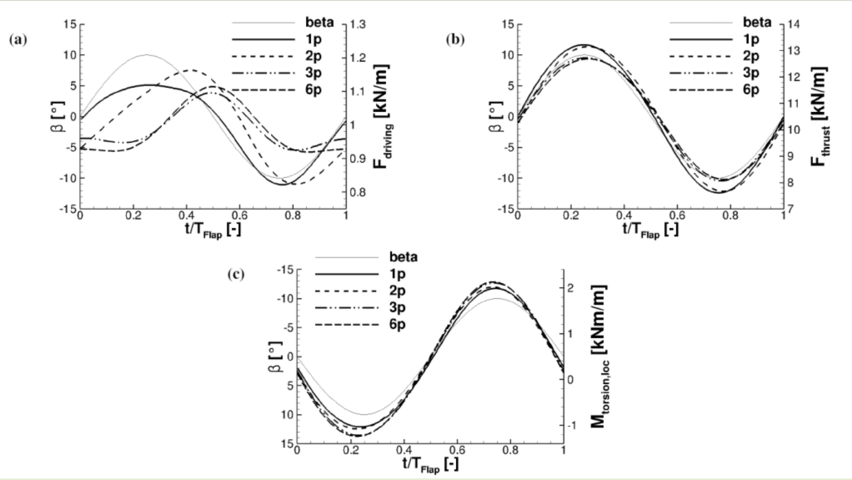

Figure 11. **Variation of flap frequency, 75 % blade cut, driving force (a), thrust (b) and local torsion moment (c)**

Page 10, line 13, "..appear (appearing).."

Thank you. The sentences are re-phrased as follows:

… The change of sign in induced velocity caused by the flap edge vortices is also apparent in the driving force as significant steps are appearing at the transition between flap and rigid

rotor part. …

Page 12, The caption of Table 2 makes no sense. Could be integral quantities for constant flap position.

Thank you, we missed a word here. Additionally, the authors suggest to use normalized integral loads with the value for β=0° to highlight the differences.

… Like for the oscillating flap cases the simulations were initiated in steady state with 16000 iterations and then restarted in unsteady mode for three turbine revolutions with a time step corresponding to 2° azimuth. This approach is plausible because the flap area is characterized by a steady flow situation as shown in similar studies (Aparicio et al., 2016b). Table 3 shows the mean integral loads of the third rotor revolution normalized with the respective value for β=0° for a relative comparison.

Table 3. **Integral loads for steady deflection normalized with value for β=0**

	$\beta = 10°$	$\beta = -10°$
Normalized power [%]	96.2	98.3
Normalized thrust [%]	103	95.2

Page 14, First sentence of section 4.3 could be re-phrased. Moreover you can define influence on what?

Thank you. This passage was re-phrased in connection to the specific comment on that section.

Page 14, line 15, ". . .but (strongly) strong.

Page 14 line 16, ". . .as driving and thrust force components.."

Page 16, first sentence, "an FFT"

Thank you. All of the above comments have been changed as specified.

Page 16, before last sentence. "In the following. . ..", please re-phrase.

Thank you. This sentence has been removed in connection to the specific comment on that section.

Page 16, line 19, "Even though a beginning hysteresis. . .", consider re-phrasing to "Even though hysteresis begins to develop in 2D. . ."

Page 18, line 8, "..with regard to. . ."

Thank you. All of the above comments have been changed as specified.

Page 19, line 4, "Unlike the oscillating cases. . ."

Thank you. The sentences are re-phrased as follows:

Unlike for the oscillating cases…

Perhaps punctuation should be also checked.

Thank you. The text was revised in this respect.