Reply on RC1
Thomas Potentier et al.

Author comment on "High-Reynolds-number wind turbine blade equipped with root spoilers. Part I: Unsteady aerodynamic analysis using URANS simulations" by Thomas Potentier et al., Wind Energ. Sci. Discuss., https://doi.org/10.5194/wes-2021-140-AC1, 2022

We thank the reviewer for the time spent reviewing the article and the feedback given. Below are the answer to the questions asked.

- The abstract has been re-written to be longer and make it clear that the paper is about 2D CFD simulations and analysis:

A commercial wind turbine blade equipped with root spoilers is analysed using 2D URANS Computational Fluid Dynamics (CFD) to assess the unsteady impact of passive devices. In this work, we present the 2D CFD unsteady results from a non-rotating single thick section located at the root end of the blade with and without spoiler. Computations were performed at the chord-based Reynolds number $Re_c = 3 \times 10^6$. The analysed spoiler is of commercial size with a height of approximately 33\% of the local chord. Comparatively to the existing literature, it is at least one order of magnitude larger than the size of the well known Gurney flaps. The analysis is first performed in the steady state at a single angle of attack using global aerodynamic forces, the local pressure distributions and flow field analysis. It shows a very important flow rearrangement in the presence of a spoiler, responsible of the mean lift force enhancement. Then, simulations are extended over a large range of angle of attack (from $-20^\circ$ to $20^\circ$), to identify the spoiler behaviour across the polar. Analyses are then continued accounting for the flow unsteadiness. The spoiler induces an important wake behaviour linked to the apparition of global load fluctuations. Using the wall pressure distributions and the associated spatio-temporal organisation of the flow field those fluctuations are well characterised. The detailed analysis performed at one angle of attack, is then extended to assesses the load fluctuations at other angles of attack, showing the evolution of the unsteady loads in relation to the wake

- Unfortunately such experimental data does not exist to the best of our knowledge, therefore we could not validate our simulations against wind tunnel measurements. However, in Potentier et al. [1] a validation of the code has been done against the existing DANAERO database for aerofoils up to 33% thick, giving confidence in our approach and results.
The Strouhal number is calculated using the definition of Yarusevych et al. [2]. As detailed on page 16 line 178 of our manuscript, the characteristic length ($L$) is the distance between two peaks of RMS of the horizontal velocity. The paragraph has been modified as follow:

In the far wake region, a single peak frequency emerges, with its harmonics, that can be extracted at $\frac{x}{c} = 3.0$ using PSD analysis (see Figure \ref{PSD_Ux_R6}). The energy content for the "no spoiler" case is several order of magnitude lower than the "spoiler" case as expected.

Figure 11. Horizontal velocity PSD, in the wake, at $\frac{x}{c} = 3.0$. The blue square (\textcolor{blue}{\large $\blacksquare$}) shows the "no spoiler" case while the orange dot (\textcolor{orange}{\Large $\bullet$}) shows the "spoiler" case.

At last, following the definition of \cite{yarusevychVortexSheddingAirfoil2009} a Strouhal number of $S_{t-spoiler}^* = 0.15$ is found. In this definition, the velocity used is the mean free stream velocity and the characteristic length ($L$) is the distance between two mean horizontal velocity Root Mean Square extrema at $\frac{x}{c} = 3.0$. The RMS peaks represents the aerofoil upper side vortex centre and aerofoil lower side vortex centre, therefore the vertical distance can be viewed as a representation of the wake width. As seen in Figure \ref{PMS_Ux_R6}, the "no spoiler" case does not present two distinct peaks, only a single bell-type curve representing the velocity deficit in the wake. On the other hand, the "spoiler" case shows a larger velocity deficit accompanied with a pair of RMS peaks showing the presence of vortices centre.

\begin{equation}
St^*_{spoiler} = \frac{f \times L}{U} = \frac{31.53 \times 0.2197}{45} = 0.15
\end{equation}

Where $f$ is the main vortex shedding frequency, $L$ is the characteristic length and $U$ the incoming velocity.\$

This result falls in line with their study where $S_t^* \approx 0.17$ was found, albeit in our case at a much higher Reynolds number and for a much thicker aerofoil and equipped with spoiler.

Figure 12. Mean Horizontal velocity Root Mean Square value for the radial position R6 at $\alpha = 6^\circ$ ($\frac{r}{R}=13\%$) and at $\frac{x}{c} = 3$. The blue square
(\textcolor{blue}{\large$ \blacksquare $}) shows the RMS for the no spoiler case and the orange dot (\textcolor{orange}{\Large$ \bullet $}) shows the RMS for the spoiler case.


- After a time step convergence study based on the chosen mesh (not initially presented in the manuscript for conciseness) we chose to use a time step of of the time necessary for an air particle to travel the chord distance. For the aerofoil and velocity used (45m/s) in the present manuscript, it is equivalent to . The difference between the chosen time step and the finest one is small enough so that the calculation time benefit outweighs the small uncertainty introduced. The following will be added to the revised manuscript:

A time step convergence study using the “Fine grid“ has also been performed and summarised in Table 3.

The chosen time step for the rest of the study is $\Delta t=4.44 \times 10^{-5}$ s because of the good balance between result accuracy and time prior convergence.

Table 3. Time step independence study for the scanned blade with spoiler at $\alpha = 0^\circ$ and $Re_c = 3 \times 10^6$

<table>
<thead>
<tr>
<th>Time step [s]</th>
<th>CL [-]</th>
<th>Extrapolated CL error [-]</th>
<th>CD [-]</th>
<th>Extrapolated CD error [-]</th>
<th>Time before convergence [min]</th>
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</thead>
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<td>2.22E-04</td>
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<td>0.08825</td>
<td>0.00%</td>
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</tr>
</tbody>
</table>

You will find in attachment a difference file between the the original and the revised manuscript. I have also attached a plot showing the good agreement between ISIS-CFD (FINE/Marine) against the DANAERO database (from comment 2) and a plot, now included in the revised manuscript, showing the RMS in the aerofoil wake.
Please also note the supplement to this comment:
https://wes.copernicus.org/preprints/wes-2021-140/wes-2021-140-AC1-supplement.zip