We appreciate the referee's careful review of this manuscript and constructive comments that we have used to improve the quality of the work. We provide the referee comments in italics and response in standard font. Proposed manuscript changes (if substantive) are in color and describe changes made in response to each comment or groups of comments.

Referee Comment: *The paper proposes an unsteady aerodynamics model for combined pitching and plunging airfoil motion. The authors compare the predictions of their model, which is based in classical aerodynamics, to CFD simulations of the NACA 0012 airfoil, with some initial validation cases around the NACA 0006 airfoil. In general, the paper is written well.*

The reviewer appreciates the idea as a potential contribution to be used in wind turbine performance codes and actuator-line methods. The originality of the idea is laudable in the sense that using concepts of classical aerodynamics to solve new problems efficiently can have notable impact.

We generally agree with the referee's summary of the scope of the work. As we hope to emphasize in the remainder of the response, studying the superposition of transverse-gust and airfoil-oscillation disturbances, even with thin airfoils, is relevant and important to the wind energy community.

Referee Comment: *The NACA 0012 is irrelevant for modern utility-scale wind turbines. As there are no experimental data available (not quite certain even) for combined pitching and plunging motion, the authors should have considered a thick cambered wind turbine airfoil for comparing their model to simulations.*

Referee Comment: *The Discussion eludes to the fact that the model would have challenges for more relevant thick airfoils.*

While a NACA 0012 airfoil is not a cambered design, it is consistent with a potential flow setup and investigation of pre-separation behavior. We do not intend this work to be a complete, all-inclusive model for blade design; we want to demonstrate how reduced-order potential-flow models for certain types of unsteady flow effects can easily be incorporated into existing BEM/ALM simulations to capture unaccounted-for physics. This strategy mirrors the development of the Beddoes-Leishman model for dynamic stall, which was originally derived for thin airfoils. Corrections already used in the literature can make this thin airfoil work apply to a broader class of shapes; we already cite the work of Lysak *et al.* (2013, 2016) on thickness corrections in the manuscript (*cf.* lines 48, 378-379, and 422-423 in the original manuscript).

Regarding validation, we do agree with the referee that the combined setup of an oscillating airfoil in a transverse gust is difficult to match in experiment, but do respectfully disagree that "there are no experimental data available … for combined pitching and plunging motion." Pitching and plunging airfoils have been extensively explored in the literature, (e.g. Anderson et al. (1998), Rival and Tropea (2010), Baik et al. (2012)), and the problem remains of research interest. For example, a newly published experimental study by Feng and Wang (2024) examines pitching motions of a NACA 0012 airfoil in a sinusoidal transverse gust and shows good agreement between measurements and potential-flow models; however we reach Reynolds numbers and reduced frequencies inaccessible by that work that are closer to those experienced in wind energy applications.

In our revised manuscript, we have better clarified how this thin airfoil theory can be connected to thicker airfoils and add comparisons to recent work that demonstrates the relevance of our investigations.

Referee Comment: *The U. Glasgow database of unsteady airfoil data (among others) could have been used as a further validation case (with more appropriate airfoils) instead of a fairly recent study on the NACA 0006, which again is irrelevant for modern wind turbines.*

A novelty of this work is examining ***superposed*** effects for such models, which are difficult to produce in lab experiments, and not only of Theodorsen-type effects and there is scant work that examines this richer parameter space at the blade section level. However, since we do not examine the dynamic stall limits at which most unsteady airfoil data used is captured, (*e.g.*, commonly-used NREL OSU data for the NACA 4415 airfoil is at a mean angle-of-attack of 8 degrees), it would not be appropriate to directly use data from most databases as validation against our simulations. The experiments with the NACA 0006 profile were the most relevant comparisons we could find in the literature due to the airfoil's alignment with the assumptions of our potential-flow based modeling approach and the similar Reynolds numbers in the experiments. As we have argued above, models that capture the dynamic stall phenomena or thick airfoil effects can be used in conjunction with our results.

Referee Comment: *In general, the authors somewhat neglect decades of work being done in unsteady aerodynamics and more suitable test cases and data that would be helpful in verifying and validating their model.*

We agree with the referee that there is a long history of work in unsteady aerodynamics, and given that this study is focused on directing some of those methods of analysis to wind-energy applications, we found it impossible to reference these works exhaustively. However, we have referenced quite a few existing studies that examine related phenomena to our specific research question (*cf.* Lines 46-54 and 66-67 in the original manuscript).

On the broader question of model development in unsteady aerodynamics, the Theodorsen function and related analytic functions are not universally utilized in the wind energy field. For example, the work of Madsen *et al.* (WES, 2020), which is used by the QBlade tool, specifically states that they do not consider Theodorsen effects. While the HAWC2 and OpenFAST modeling frameworks use semi-empirical Beddoes-Leishman inspired models to capture these effects, even research-grade large-eddy simulations (LES) of wind turbines and wind farms, such as the LESGO or Nalu-Wind codes, use actuator-disc models (ADM) and actuator-line models (ALM). Such LES employ quasi-steady aerodynamics *e.g.* a constant specified thrust coefficient (for ADM) or airfoil lift-drag polars from steady-flow measurements (for ALM).

In our revised manuscript, we have clarified the relevance of our work to the wind-energy community and offered commentary on limitations and advantages of our chosen problem setup.

Referee Comment: *In its present form, the reviewer cannot implement the unsteady pitching and plunging model into a BEMT code as not enough information is given. There is not even a nomenclature in the paper.*

We agree with the reviewer that this final critical application step could be better clarified in the manuscript. As we propose a modification to the standard lift coefficient calculations, this model is relatively simple to implement in a BEM code, where further corrections to account for finite thickness and camber are already present. For example, to implement in AeroDyn, which underpins OpenFAST, we would modify the static inviscid lift coefficient $C_l^{st}(\alpha)$ as it is defined in the theory manual. This would be similarly done in other codes and is entirely consistent; for example, HAWC2, notes that part of its unsteady aerodynamics modeling involves merging "a thin-airfoil potential flow model ... with a dynamic stall model of the Beddoes-Leishmann type."

In our revised manuscript, we have better clarified exactly how one would use our results in a larger turbine simulation code.

Referee Comment: *It is unclear in section 3.2 which part of the rotor disk (radius, azimuth) is most affected by plunging and pitching motion.*

Referee Comment: *Similar in section 4.1. Where on the rotor disk of a modern wind turbine are these scenarios relevant?*

In this work, we examine the problem at the blade section level, where location on the rotor disk is an input to the model and is not explicitly necessary. However, practically speaking, we would expect pitching and plunging motions will manifest more readily further from the blade root.

We will add reference in our introduction to specific areas on the rotor disk where the pitching and plunging motions will be dominant.